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13. ABSTRACT (Maximum 200 words)

Prof. Ostachowicz presented a seminar to the Aeropropulsion Laboratory, Dayton, Ohio on 5 May 1992 concerning: stress-strain analysis of a turbine blade root, vibrations of turbine and compressor blades, stiffness matrices of cracked finite elements, and vibrations of a cracked rotor and a cracked turbine blade.

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2 June 1992

R E P O R T

Ref.SPC-92-4012

Date of the visit: 5-7 May 1992

Date of the Seminar: 5 May 1992 (Main Conference Room)
45 min.+25 min.discussion

Place of the Seminar: Wright-Patterson Air Force Base
Aeropropulsion Laboratory
WL/POTC Dayton OH 45433-6563

Persons who listened the Seminar: Capt.Richard Heim and ca 16 persons(between others Capts.Driver and Murawski)
Also I met Dr.J.S.Przemieniecki, Senior Dean of the Air Force Institute of Technology.

In the first part of the seminar I briefly described activity of the Institute of Fluid Flow Machinery, Polish Academy of Sciences. In particular I presented the activity fields of its 10 departments.

In the second part I presented the following topics:

- *Stress-strain analysis of a turbine blade root*

The object of analysis is stress-strain problem in turbine and compressor blade roots including contact problems. A blade root and a fragment of disk are modelled by 3-dimensional finite elements. We used the finite element with 20 nodes (60 d.o.f). The discrete model contains superelements. On a surface between a blade root and a cut of a disk we introduced special point finite elements which model sliding and broken properties of a joint. Using this model we can calculate stresses including adhesion, sliding (Coulomb forces) and broken contact. The calculations were provided for elastic and elasto-plastic properties of a material. During the seminar I presented results of calculations for the real system.

- *Vibrations of turbine and compressor blades*

The object of analysis are vibrations of blades. Blades were modelled by finite elements. We used 3-dimensional finite elements (8-node, 16-node or 20-node), thick shell finite elements and transition finite elements. We formulated four models of a blade. Each model contained the combination of described above finite elements. We considered separately short and long blades and also special blades (for example the blades of Baumann stage). During the seminar I presented results of calculations for three first natural frequencies. Numerical calculations were compared to experimental results. The best results we obtained for the model which contained both 3-dimensional FE (20-node), thick shell FE and transition FE.

- *Stiffness matrices of cracked finite elements*

A crack in a structure causes local changes in stiffness. These changes, in turn, affect the dynamics of the system. Both frequencies of the natural vibrations and the amplitudes of forced vibrations are changed. During the seminar I presented the method which we used to formulation of stiffness matrices for few cracked elements. I described these matrices for the following finite elements: bar, beam, disk, plate, solid. The examples illustrated the possibilities of calculations and also their accuracy. We compared the results of numerical calculations to analytical results and also to experimental data.

- *Vibrations of a cracked rotor and a cracked turbine blade*

Using described above stiffness matrices we analyzed the influence of cracks on the natural frequencies of torsional and bending vibrations of rotor shaft and turbine blades. Also dynamic instability of cracked beams were considered. During the seminar I presented the results of calculations which illustrated changes of dynamic properties of cracked structures. Natural frequencies decrease their values when the depth of a crack increases. These frequencies also depend on location of cracks. I discussed the results of forced vibrations. In particular I explained the dependence between crack's properties and amplitudes of vibrations. Also the dependence between the regions of dynamic instabilities and crack parameters were discussed.